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SPILLOVER DIFFUSION AND REGIONAL CONVERGENCE: A GRAVITY APPROACH

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Spillover diffusion and regional convergence: a gravity approach[1]

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ABSTRACT

Among the different sources of regional growth, agglomeration economies, both internal to regions and external to regions (spillovers) play a primary role. However the presence of agglomeration economies may obstacle the path toward cohesion making rich (poor) regions become richer (poorer). While, according to New Growth Theory and New Economic Geography, there is no doubt that internal economies may lead to divergence, the debate on the role of external economies on convergence is still open. Much, of course, depends on the spatial extension of spillovers. The aim of this work is to study the spatial dimension of spillovers using the framework of cross-region growth regression. In particular we seek to explain whether the intensity of spillover is either completely exogenous or it can be explained by some endogenous regional characteristics. Results indicate that the intensity of externalities is determined by a) the regional geographical position and b) the distance from neighbors with high growth rates. While the first is completely exogenous, the second is not. Curiously enough, infrastructural endowments and factors commonly assumed to induce agglomeration do not contribute to explain the intensity of spillovers. Results have important policy implications. Since spillovers characterize more core regions, which are well connected to other rich regions, than periphery, the presence of these externalities may foster the increase of disparities between core and periphery, making harder to reach the objective of cohesion.

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INTRODUCTION

The aim of this paper is to investigate the spatial dimension of growth spillovers within the framework of the convergence process in European Union at regional level. Regions are the main objective of European Cohesion Policy, both because they represent an intermediate political level between states and local administrations and because they are the main funds receivers. A convergence process is expected to take place in European regions since efforts have been done in order to remove barriers to flows of goods and services. Moreover, labor and capital mobility should have contributed to convergence re-equilibrating differences between factors' productivity and revenues in eastern and western Europe, as neoclassical theories would predict (Solow, [28]).

However, growth does not result only from capital accumulation under exogenous and constant technological change. Scholars have emphasized the contribution of increasing returns to growth in the form of knowledge spillovers (Romer, [26]) and agglomeration externalities (Krugman, [17]). Spillovers and externalities may contribute to convergence in different ways. On one side they can foster growth in already developed regions stimulating the mechanism of *cumulative causation*. In such a case economies will diverge in the long run. On the other side it is possible that spillovers and externalities cross regional borders, reaching other regions that may eventually benefit in terms of growth. It is therefore quite evident that, as Grossman and Helpman [13] pointed out, the effect on growth of spillovers and externalities will depend on the spatial dimension of these lasts[3].

Empirical strategies adopted to estimate the contribution of spillovers and externalities to growth involves the use of spatial econometric tools. After the work of Rey and Montouri [25], spatial econometric methods have become the mainstream approach to study spillovers and in this direction can be considered, among the others, the works of Neven and Gouyette [21], Ertur et al. [9], Bosker [7], Brauninger and Niebuhr [8], and Fischer and Stirböck [12]. Most of these studies concentrate on the presence of regional patterns of convergence in EU, differentiating agglomerated from non agglomerated areas and core from periphery regions, highlighting evidences of *club-convergence*. In any of the cited studies, empirical evidences based on European regional data suggest the presence of positive interregional spillovers.

Couriosly, not so much attention has been paied to what is behind the mechnaism of spillover[4], and in particular what are the regional characteristics allowing spillovers and externalities to be more easily exchanged across regional borders. This paper attempts to do so modelling the continuity matrix, useful to define the sets of neighbors to be used in spatial econometric models, according to a gravity approach. In the basic formulation of the gravity approach the amount of interaction (attraction) of two regions (bodies) is a positive function of some regional (body) mass and a negative function of the distance separating them. Using data on 243 EU regions belonging to 24 member states we first search for the contiguity matrix best representing the structure of the linkages among European regions, and then apply a gravity formulation in which several definitions of regional *mass* are used in order to account for economic and social interactions and for the role of infrastructures.

The remaining of the paper is organized as follows. Next section introduces to the subject of regional convergence and territorial cohesion, presenting the European Commission perspective. The aim is to highlight why it is worth focusing on matters like agglomeration economies, peripherality and transportation infrastructure in a discussion on regional convergence. Section 3 shortly describes the empirical model and the source of data. Section 4 is dedicated to empirical results. Follow some discussion and conclusions.

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[3] Hereafter the words *spillovers* and *externalities* will be both used to identify externalities crossing regional borders.

[4] With the exception of studies on the knowledge spillovers (Audretsch & Feldman, [4])

REGIONAL CONVERGENCE AND TERRITORIAL COHESION

The role and the importance of disequilibria among European regions are clearly stated in the EU Treaty where territorial cohesion is introduced along with economic and social cohesion (art.174). Furthermore, the Treaty clarifies that a "particular attention shall be paid to rural areas… and regions which suffer from severe and permanent natural or demographic handicaps such as the northernmost regions with very low population density and island, cross-border and mountain regions" (art.174).

The emphasis on disparities is largely discussed in the sequence of reports on cohesion among regions and countries published by the EU Commission. Most of them are widely used as basis to cohesion policies. The latest evidence provides a contradictory picture of the phenomenon. On one side economic cohesion among countries has improved due to relevant performance of the so-called "cohesion countries" (countries with per capita GDP lower than 90% of European average) like Ireland and Spain that reached the top levels of European ranking. On the other side, cohesion among regions globally improved since eight regions over 78 overcome the 75% of per capita GDP (EU-27). Despite the low number of regions involved by a significant improvement, the fourth relation on social cohesion states that "The lagging regions in the EU-15, which were major recipients of support under cohesion policy during the period 2000-2006, showed a significant increase in GDP per head relative to the rest of the EU between 1995 and 2004. In 1995, 50 regions with a total of 71 million inhabitants had a GDP per head below 75% of the EU-15 average. In 2004, in nearly one in four of these regions home to almost 10 million, GDP per head had risen above the 75% threshold."

Territorial cohesion exhibited an evidence of an increasing number of poles of development. Most of these poles are concentrated in large urban areas, in EU-15 regions as well as in the enlargement countries. A symmetric phenomenon of decreasing economic activities in rural areas emerged. Until the nineties the core of the European growth was concentrated in the middle of EU-15 (Munich, Hamburg, Paris, London and Milan). Afterwards, the new comers of European economic growth emerged in Scandinavian countries, Spain and Ireland and in the capital towns of the enlargement countries. The polarization of the economic development has largely been characterized by increasing diseconomies of agglomeration, due to increasing congestion costs and pressure on housing markets and network services, and subsequent suburbanization. Despite an increasing optimistic view about economic convergence among EU regions, the analysis of EU policy-makers about territorial cohesion is focused on the potential problems arising from growth polarization. Large capital towns (or better capital regions) often became strong economic growth attractors but, at the same time, increasing problems in surrounding regions and deprivation in rural areas offset the economies of agglomeration generated by increasing growth rates. Their core-peripheral dynamics is often characterized by relevant economic growth and loss of population at the core of capital region and less moderate economic growth and increasing population at the periphery of capital region (urban sprawling). In some countries economic growth is characterized by a bi-modal (or tri-modal) distribution of regional growth rates with a leading town/region (usually the capital town region) and strong secondary poles (like Milan and Naples in Italy, Barcelona in Spain, Frankfurt and Munich), where economic growth is even higher than in the capital town. Usually, most of the economic growth is concentrated in the capital town region and less distributed in the rest of the country. Moreover, most of the economic potential is concentrated, according to EU analysis, in cross-border cooperation due to relaxation of constraints to economic exchanges from physical and administrative point of view. Cross-border areas are certainly in some cases consolidated areas of spillover effects in economic growth and in other cases, where the physical context is an obstacle, are marginal areas due to lack of infrastructure (i.e. mountain areas).

Territorial and economic differences in EU regions are also clearly due to different development patterns among European regions. Looking at the latest years (1995/2005), there have been at least three different situations: in some regions high growth rates in per capita GDP have been obtained along with increase in productivity and in employment rates: ie. the case of Ireland; in some other regions, relatively high growth rates in per capita GDP have been obtained along with increase in productivity and strong decline in employment rates; in other regions, most of them in highly industrialized countries, lower (or negative) per capita GDP growth rate are accompanied by low productivity growth rate and by moderate employment rate growth.

The current economic crisis will certainly re-depict the current situation, since some of the new member states might be interested by structural crisis. Nevertheless, the underlying fundamentals of economic structure will strongly influence the recovering phase and the productivity patterns will be crucial. The empirical evidence and most of the analysis of territorial cohesion are openly oriented to discuss how space may matters in the dynamics of convergence among European regions. Some very practical questions may arise. Are agglomerative factors crucial to explain increasing economic convergence? Is increasing economic convergence widely justified by current cohesion policies? Is there any additional room to stimulate spillover effects by supporting specific cooperation policies? Are spillover effects still relevant in a dematerialized economy in which geographical proximity may reduce its importance?

METHODS AND DATA

The idea of economic convergence is derived from neo-classical growth models (Solow, [28]) in which, under simple hypothesis of constant returns to scale, perfect competition and homogeneous agents, it is shown that all the economies with similar characteristics converge to a long-run level of per-capita income. Barro-type regressions (Barro and Sala-i-martin, [5]), in which regional growth is explained by the initial income level, have been used to search evidences of income convergence[5]. Using the notion of *conditional convergence*, the model is generally augmented with some control variables in order to account for heterogeneity in structural characteristics. However, the lack of data at regional level has made harder the work of scholars interested in investigating the causes of regional development. Attempts in such a direction have been made by Islam [15], who first introduced fixed effects estimators in growth regression, Paci e Pigliaru (2001) accounting for technological disparities and Fagerberg and Caniels [16] introducing differences in labor market conditions.

The advantage of spatial econometric models is evident: on one hand it is possible to account for unobserved (and usually unobservable because of data missing) heterogeneity (LeSage & Pace, [19] and Elhorst, [11]), provided that neighboring regions have similar characteristics; on the other hand these methods allow to introduce and measure the effect of spillovers and externalities external to regions, the outcome of the interaction process. Basically a spatial econometric formulation of the growth regression can be obtained augmenting the Barro-type model (1)

$$\frac{1}{T}\log\left(\frac{gdp_{i,t+T}}{gdp_{i,t}}\right)_i = a + b\log\left(gdp_{i,t}\right) + e_i \tag{1}$$

(in which the term in the left-hand side is the annual average growth rate over a period of T years) with a spatially lagged dependent variable (Spatial Lag Model (2)), a spatially lagged initial income (Spatial Cross-Regressive Model (3)) or modeling the error term as a simultaneous autoregressive process (Spatial Error Model (4)) (Rey & Montouri, [25]).

$$\frac{1}{T}\log\left(\frac{gdp_{i,t+T}}{gdp_{i,t}}\right)_i = \rho W \frac{1}{T}\log\left(\frac{gdp_{i,t+T}}{gdp_{i,t}}\right)_i + a + b\log\left(gdp_{i,t}\right) + e_i \tag{2}$$

[5] This kind of models represents the workhorse of growth theorists although it has been criticized (Quah, [23], [24] and Durlauf & Quah, [10]) because the evidence it provides is necessary but not sufficient to argue in favor of real income convergence, measured as a reduction of disparities over time.

$$\frac{1}{T}\log\left(\frac{gdp_{i,t+T}}{gdp_{i,t}}\right)_i = a + b\log\left(gdp_{i,t}\right) + \gamma W \log\left(gdp_{i,t}\right) + e_i \qquad (3)$$

$$\begin{cases} \frac{1}{T}\log\left(\frac{gdp_{i,t+T}}{gdp_{i,t}}\right)_i = a + b\log\left(gdp_{i,t}\right) + e_i \\ e_i = \lambda W e_i + u_i \end{cases} \qquad (4)$$

Elhorst [11] gives evidence of how to nest the three models in (2), (3) and (4) in a more general formulation, the Spatial Durbin Model, which is basically a model with both a lagged dependent and independent variable on the right hand side.

W is a standard $n \cdot n$ contiguity matrix, with n the number of observations, whose element w_{ij} is non-zero if region i and region j are neighbors. Different approaches can be used to define contiguity, namely *k-nearest*, *great circle distance* and *common border*. Among these three criteria the last is the less used because, in case of islands, it is likely to produce regions with empty neighbors sets. Regression results are generally quite sensitive to the choice of the contiguity matrix and sensitivity analysis is usually necessary. And that is the reason why two points are worth to discuss here before presenting empirical results.

First it would be misleading to interpret the choice of the correct W matrix as the simple outcome of model comparison based on measures of statistical fitting. The matrix in itself in fact contains information about the structure of linkages that is assumed to exist among the economies. Such a structure is of fundamental importance in the understanding of how regions affect each other in the growth process. Figures 1 shows the map generated connecting regions according to two criteria used in next section to construct contiguity matrices.

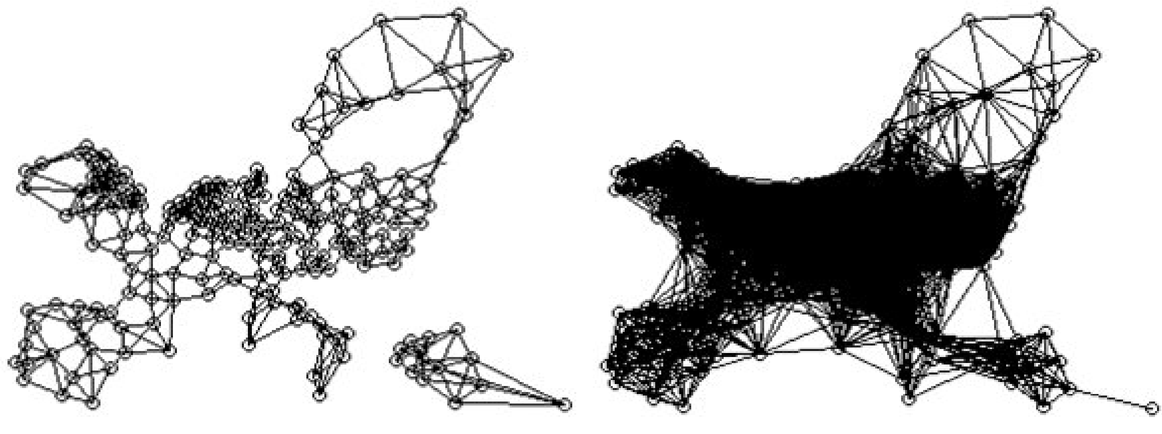

Figure 1: k-nearest (left) and distance (right) contiguity

In the case of *k-nearest* criterion *k* has been set to 4 and distance has been set to the distance allowing no regions to appear as islands. A first look reveals that the second structure weights more the central positioning of regions attributing a less complex structure to regions in the periphery. The main assumption behind the first kind of contiguity structure is the homogeneity of linkage structures across regions. It means that regions hosting capital cities and metropolitan areas like Brussels, London, Milan, Hamburg of Frankfurt have the same connectivity structure of peripheral regions like Cyprus, southern Italy’s regions, or Ireland. It looks that, beyond the statistical goodness of fit of each matrix, the distance method leads to a more realistic structure of linkages, because of the different ways core and periphery are taken into account.

Secondly, common practice in spatial econometric is to assign a value equal 1 to all non-negative elements of the W matrix. In this way the matrix will result as a binary contiguity matrix. In practical use the matrix is row-standardized and the lagged value of a random vector, say z can be therefore interpreted at the average value of z in neighboring regions. Although having the great advantage of letting the weight matrix to be completely exogenous, the binary choice is far from innocent because it assumes that each of the neighbors of a region gives the same identical contribution to regional growth in the destination region. To some extent this may look as an excessive simplification, as the intensity of relationships between two neighbors is not completely exogenous but instead may depend on some regional characteristics. Such a non-binary choice for the contiguity structure would lead to a weight matrix such that the lagged value of z would be interpreted as the weighted average of z in neighbors. Weights allow to attribute a stronger connection, and consequently higher spillover flows, to regions where certain characteristics are abundant. According to theoretical models of New Economic Geography, interactions among economies is determined by low distances and reduced transportation costs in general (Krugman and Venables, [18]). Agglomeration forces make the rest attracting workers and/or firms in already developed regions.

Interactions among economies should be therefore modeled according to these evidences; in other words linking the intensity of interactions with distance, transportation costs and agglomeration economies. To that purpose some special weight matrices have been also used, whose elements are constructed according to the following gravitational law (Sen and Smith, [27], Toral, [29]):

$$w_{ij} = \frac{Size_i \cdot Size_j}{dist_{ij}} \tag{5}$$

in which $dist_{ij}$ is the physical distance between centroids or regions i and j, and $Size$ is a measure either of infrastructural endowments (kilometers of road or motorways), proxy for low transportation costs, or of agglomeration economies (Gross Domestic Product or population because of possible GDP endogeneity).

All the data used in the empirical model come from Eurostat regional database. Regions are selected according to NUTS II classification. GDP is measured in Purchasing Power Standards per inhabitant at constant prices and growth rate has been computed for the period 1995-2006. Data on Population (number of inhabitants), Km of roads and motorways refer to nearest year to 1995 for which data were available (mostly 1995). Geographical information have been obtained making use of data and maps available at Eurostat Geographical Information section, GISCO.

RESULTS

This section provides empirical results of the analysis. To start with the simplest specification, a standard cross-region regression has been estimated for our sample of 243 regions. The dependent variable is the annual average growth rate for the period 1995-2006.

In table 1 the coefficient on the log of initial income level indicates that there has been some convergence during this period. However several tests on estimated residuals confirm that errors are not normally distributed and that are spatially auto-correlated. The general evidence of spatial autocorrelation is robust to several specifications of the contiguity matrix. After testing this hypothesis with two sets of k-nearest based and distance based matrices, the values of k and d have been chosen according to the maximum level of Log-Likelihood achieved when such matrices have been used in estimating Spatial Models. According to this criterion, $k = 4$ and $d = \max\left(\min_j \left[d_{ij} \right]\right)$[6], are the best matrices to be used. Results in table 1 have been obtained using these matrices.

OLS Estimates		
Constant	0.202349 (11.896) ***	
LN GDP95	-0.016663 (-9.347) ***	
Adj R-Squared	0,182638889	
F(1,241)	87.36 ***	
Log-Likelihood	7.472.297	
Akaike Information Criterion	-1.488.459	
	Spatial Autocorrelation Diagnostic	
	distance method	k-nearest method
Moran I on residuals	0.170	0.317
LM-Lag	112.29 ***	75.58 ***
LM-Err	104.42 ***	55.52 ***
Robust LM-Lag	19.29 ***	21.63 ***
Robust LM-Err	11.41 ***	15.68
Note: ***, ** and * respectively indicate significance at 1%, 5% and 10% confidence levels. t-statistics in parenthesis		

Table 1 Cross-regional growth regression results

For what concerns spatial autocorrelation diagnostics, Moran I index is constructed according to Moran [20] and LM tests are the statistics proposed by Anselin [2]. While I index is only used in order to explore whether the spatial distribution of error terms departs from the standard normal one, LM statistics, in their simple and robust versions, can be used for model selection purposes. The specification with the highest value of LM statistic is generally chosen and in case both are strongly significant the robust version of the test should indicate which one of the two specifications should be chosen. With both distance and k-nearest matrices results clearly indicate that spatial lag is the best choice, as LM tests are both significant with both matrices and robust LM tests achieve higher scores when the Lag specification is the alternative (in the case of k-nearest matrix the robust test on the Error alternative is also insignificant).

Table 2 reports results of estimation of the four possible spatial model specifications with both matrices. (a) indicates that the model is estimated making use of the matrix constructed with the

distance criterion; (b) indicates the same with k-nearest criterion. With respect to the convergence

[6] This is the distance such that any region has at least one neighbor and corresponds to the distance separating Cyprus from eastern Greece.

	Spatial Lag		Spatial Error	
	(a)	(b)	(a)	(b)
CONST	0.089 (4.88) ***	0.095 (5.53) ***	0.135 (6.01) ***	0.1200475 (5.3153) ***
LN GDP95	-0.008 (-4.82) ***	-0.008 (-4.80) ***	-0.009 (-4.0353) ***	-0.008 (-3.39) ***
LAGGED LN GDP95	- -	- -	- -	- -
LAGGED GR RATE	0.794 (10.57) ***	0.567 (9.58) ***	0.849 (12.45) ***	0.595 (9.98) ***
Likelihood Ratio	54.032 ***	65.784 ***	45.215***	51.94 ***
Wald test / F Statistic	111.72 ***	91.94 ***	154.93 ***	99.67 ***
Log-Likelihood	774.2455	780.1217	769.8374	773.1996
Akaike information Criterion	-1540.5	-1552.2	-1531.7	-1538.4
LM test on residual autocorrelation	0.11062	4.914 ***	-	-

Note: ***, ** and * respectively indicate significance at 1%, 5% and 10% confidence levels. z-statistics in parenthesis (t-values only in Spatial Cross-Regressive model). LAG

Table 2: Spatial models estimates with both distance (a) and k-nearest (b) contiguity matrices

hypothesis, the inclusion of a spatial effect in any of the possible ways does not alter the slope and the significance (except for two cases) of the convergence coefficient. However the magnitude of this coefficient is lower than that estimated without spatial effects. With respect to the spatial autoregressive coefficient either of the dependent variable or of the error term, it is always positive and significant. It is worth to note that it is also higher in cases a distance matrix is used.

As far as it concerns model choice, it seems that, as predicted by LM statistics, the Spatial Lag Model is a preferred specification. The inclusion of a spatial lag of the initial income level (i.e. Spatial Durbin Model or Common Factor Hypothesis) does not alter so much the value of coefficient. However either the initial income or its lagged value turn to be insignificant depending on the matrix used.

Using the Spatial Lag model as reference specification the effect of agglomeration economies on spillovers has been tested. Using GDP $[Y]$ as size of economic activity (or POP $[P]$ to avoid problems of endogeneity) and km of roads $[R]$ or motorways $[M]$ as size of transportation infrastructures, and euclidean distance $[D]$ as proxy for transportation costs, different contiguity matrices have been constructed (table 3).

Model	Specification of matrix elements
W	$w_{ij}, binary$
W/D	w_{ij} / d_{ij}
W/D2	w_{ij} / d_{ij}^{2}
YY/D	$gdp_i \cdot gdp_j / d_{ij}$
PP/D	$pop_i \cdot pop_j / d_{ij}$
MM/D	$km_i^{mways} \cdot km_j^{mways} / d_{ij}$
RR/D	$km_i^{road} \cdot km_j^{road} / d_{ij}$

Table 3: List of contiguity matrices

All the matrices in table 3 have been used to estimate the Spatial Lag Model for the cross-regional regression with both k-nearest and distance matrices. Results are respectively in table 4 and 5. Significance of coefficients is maintained in all models and also the values of slopes are not affected by the matrix choice. The coefficient on initial income level is always around the value of -0.008, while the lagged growth rate coefficient is around 0.56 in the case of k-nearest contiguity and 0.75 in the case of distance contiguity; which brings to the conclusion that, independently of how spillovers are affected by agglomerations, externalities contribute to growth much more than the convergence effect does.

To test the hypothesis of relevance of agglomeration economies we can compare the likelihood of different models. However, because models are non-nested, it is not possible to use likelihood ratios. In the case of k-nearest contiguity there are evidences of agglomeration economies and in particular of the role of distance. Introducing simple distance between neighbors produces an increase of the likelihood of the model together with the use of cross-product of income and km of roads, while km of motorways do not help explaining spillovers.

The main problem with the use of k-nearest distance matrix is that model residuals show traces of autocorrelation even after the inclusion of the spatially lagged growth rate. This can be noted looking

ML Estimates: k-nearest contiguity								
	Coefficients							
Model	CONST	INIT INC	LAG GR	LR	W Stat	LL	AIC	LM
	(z-stat)	(z-stat)	(z-stat)	(p-value)				(p-value)
W	0.095 (5.53)	-0.008 (-4.80)	0.5668 (9.59)	65.78 (0.000)	91.94 (0.000)	780.12	-1552.2	4.91 (0.026)
W/D	0.095 (5.61)	-0.008 (-4.84)	0.564 (9.90)	70.53 (0.000)	98.08 (0.000)	782.50	-1557	6.85 (.009)
W/D2	0.099 (5.92)	-0.008 (-5.07)	0.537 (9.73)	70.5 (0.000)	94.68 (0.000)	782.48	-1557	10.57 (0.001)
YY/D	0.095 (5.62)	-0.008 (-4.85)	0.563 (9.89)	70.68 (0.000)	97.80 (0.000)	782.57	-1557.1	6.92 (0.008)
PP/D	0.094 (5.62)	-0.008 (-4.85)	0.562 (9.86)	70.15 (0.000)	97.16 (0.000)	782.31	-1556.6	6.99 (0.008)
MM/D	0.106 (6.08)	-0.009 (-5.27)	0.515 (8.61)	61.62 (0.000)	70.09 (0.000)	778.04	-1548.1	11.29 (0.000)
RR/D	0.094 (5.57)	-0.008 (-4.81)	0.567 (10.00)	70.83 (0.000)	100.02 (0.000)	782.63	-1557.3	5.76 (0.016)

Note: Indicators of z-values confidence levels omitted: all coefficients are strongly significant. LR test refers to the null hypothesis of coefficient of LAGGED GR=0.

Table 4: Spatial Lag model – gravity approach to k-nearest contiguity matrix

at values of LM statistics. The null hypothesis of absence of autocorrelation in residuals of the Spatial Lag Model is rejected at 5% confidence level in all the models. To some extent this indicates that some residual spatial heterogeneity may not be captured by the model.

ML Estimates: threshold distance method								
	Coefficients							
Model	CONST	INIT INC	LAG GR	LR	W Stat	LL	AIC	LM
	(z-stat)	(z-stat)	(z-stat)	(p-value)				(p-value)
W	0.089 (4.88)	-0.008 (-4.83)	0.795 (10.57)	54.03 (0.000)	111.65 (0.000)	774.24	-1540.5	0.11 (0.74)
W/D	0.076 (4.40)	-0.007 (-4.26)	0.817 (13.21)	71.95 (0.000)	174.43 (0.000)	783.21	-1558.4	0.67 (0.41)
W/D2	0.077 (4.50)	-0.007 (-4.19)	0.742 (12.12)	82.49 (0.000)	146.87 (0.000)	788.48	-1569	1.70 (0.19)
YY/D	0.104 (5.47)	-0.010 (-5.46)	0.754 (8.46)	43.42 (0.000)	71.51 (0.000)	768.94	-1529.9	2.77 (0.09)
PP/D	0.1021 (5.33)	-0.009 (-5.33)	0.752 (8.46)	44.45 (0.000)	71.66 (0.000)	769.45	-1530.9	2.61 (0.11)
MM/D	0.106 (5.69)	-0.009 (-5.62)	0.717 (7.22)	42.66 (0.000)	50.20 (0.000)	768.56	-1529.1	3.93 (0.047)
RR/D	0.102 (5.28)	-0.009 (-5.28)	0.748 (8.36)	43.53 (0.000)	69.68 (0.000)	768.99	-1530	2.19 (0.14)

Note: Indicators of z-values confidence levels omitted: all coefficients are strongly significant. LR test refers to the null hypothesis of coefficient of LAGGED GR=0.

Table 5: Spatial Lag model – gravity approach to distance contiguity matrix

A different picture emerges looking at the results with distance method matrix. Here the only factor of the gravity approach that contributes to increase the likelihood of the model is distance. And in particular the squared distance is what allows the model to reach the highest likelihood. The relevance of squared distance is justified with the fact that the average distance from neighbors is relatively higher using distance matrix compared to that obtained using k-nearest matrix. The inclusion of other measures of agglomeration effects like income and/or infrastructure does not positively impact the likelihood of the model.

Contrary to what happens with k-nearest matrix, there is no trace of auto-correlated residuals in the models of interest (i.e. with distance and distance squared in the denominator). The fact that distance squared produces the best contiguity matrix has some important implications. Firstly, such a distance is about 700 km, which means that growth externalities are quite localized or at least localized enough to prevent growth benefits to flow from the core to the periphery of Europe, if not after decades. Secondly, the squared distance indicates that half of spillovers are confined within one fourth of the distance. And this means that real spillovers benefit are bounded in a circle of less than 200 km from the origin.

DISCUSSION

The focus of the work was to discuss the aspects linking economic convergence to agglomeration economies and externalities. With respect to the first aspect, economic convergence, results drive in the direction of giving support to the theory according to which poor and peripheral EU regions, mostly located in New Member States, are having higher growth rates. This is without doubt a source of economic convergence. On the other side it is worth to note that this convergence rate is relatively low with respect to what is needed to reduce disparities in the long run. With respect to the second aspect, agglomeration economies and externalities, results indicate that externalities external to the region play a very important role in regional growth.

However spillovers (external externalities) cannot be considered as a source of convergence as long as benefits produced by the mechanism of diffusion are not homogeneously distributed across space. And results indicate that they actually are not. A contiguity matrix assigning the same number of neighbors to all regions (homogeneous distribution of externalities) is not sufficient to account for the spatial relations occurring among regions in growth dynamics, as residuals of the models estimated using this matrix are auto-correlated in any case. On the contrary, a contiguity matrix reflecting a stronger connectivity of regions in the centre and a poor network structure of regions in the periphery has to be preferred.

Moreover, applying a gravity structure to the elements of the distance matrix does not improve the likelihood of the model, except for using the inverse of squared distances between neighbors as elements of the matrix. None of the sources of agglomeration economies suggested by NEG literature helps to explain the intensity of these external externalities. On one side this may be the result of the fact that distance itself captures most of the *transportation cost effect*, therefore making not necessary the use of a proxy for infrastructure endowments. On the other side it can be also due to the use of a distance matrix that already weights more the central position of a region and, consequently, its proximity to other reach regions.

Finally, evidences suggest that spillovers are geographically bounded and the majority of benefits are spent within less than 200 km from the origin region. This has very important implications in terms of convergence because implies that regional growth in the periphery is not affected by growth in the core. In synthesis the intensity of spillovers between neighbors is not completely exogenous. But, at the same time, it is not determined by economic and structural characteristics of regions. On the contrary it seems that the intensity of flows of this externalities between neighbors is affected by the geographical location of the region (core vs periphery, which means proximity to vs distance from other rich regions) and by the distance separating the destination from the origin.

CONCLUSION

Evidences found in this work suggest the presence of different patterns of growth. On one hand the core of Europe, characterized by a very intense network structure, in which growth has been lower but regions have benefited of growth externalities. On the other hand the periphery of Europe, in which growth has been higher in last decade due to the effect of economic convergence, but that have not benefited of externalities. This has very important policy implications that are worth to note. In particular there is a trade-off between cohesion and competitiveness. As growth in the core is sustained by the mechanism of cumulative causation and is reinforced by the fact that rich regions are well connected to each others, this development model will continue to increase the competitiveness of regions in the core. Nonetheless, if externalities are typical of the core and are also bounded within very short distances, this will prevent the benefits of this increase in competitiveness to reach peripheral regions. And in turn this will inevitably obstacle the process of cohesion within European area.

In order to achieve the cohesion objective, European policies should not only rely on the natural higher growth in poorer and peripheral regions, but should also think on how to stimulate growth in these regions making them benefit from the process of cumulative development of the core.

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